International Civil Aviation Day
The Greening of Flight

Jane Hupe
Chief, Environmental Unit
Key Environmental Issues

Noise

dB

Key Environmental Issues

Aircraft Engine Emissions

CO

HC

CO2

NOx
Context

- Fuel / energy
- Emissions at high altitudes (8 to 13 km)
- Adverse meteorological conditions
- Past / future growth
Context

- Alternative aircraft fuels
- Fossil fuels
- Carbon Dioxide (CO₂)
- Carbon Dioxide (CO$_2$)
- Lasts around 100 years in the atmosphere
Context

- Fuel / energy
- Emissions at high altitudes (8 to 13 km)
- Past / future growth
- Adverse meteorological conditions
Challenges for States and ICAO

- How to find an appropriate balance between future growth and environmental problems?
- How to accommodate States’ very different views within a harmonized worldwide approach?
ICAO Assembly

Council

Air Transport Committee

Air Navigation Commission

Committee on Aviation Environmental Protection
Technical feasibility

Environmental effectiveness

Economic reasonableness

Interdependencies of measures
CAEP *Members* and Observers

Argentina  India  South Africa
Australia  Italy  Spain
Brazil  Japan  Sweden
Canada  Netherlands  Switzerland
Egypt  Poland  Tunisia
France  Russian Federation  United Kingdom
Germany  Singapore  United States
### CAEP Members and Observers

<table>
<thead>
<tr>
<th>Country</th>
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<th>Organization</th>
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<td>Greece</td>
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*Environmental NGO umbrella group*
A35-5
Consolidated statement of continuing ICAO policies and practices related to environmental protection
Appendix H: Environmental impact of civil aviation on the atmosphere

Appendix I: Market-based measures regarding aircraft engine emissions
Standards and Recommended Practices

Annex 16, Vol II

Environmental Protection

Volume I
Aircraft Noise

International Standards and Recommended Practices

Annex 16 to the Convention on International Civil Aviation

This edition incorporates all amendments adopted by the Council prior to 27 February 2005 and approved, on 24 November 2005, all previous editions of Annex 16, Volume I. For information regarding the applicability of the Standards and Recommended Practices, see Forward.

Fourth Edition
July 2006

International Civil Aviation Organization

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES
ENVIRONMENTAL PROTECTION
ANNEX 16
TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME II
AIRCRAFT ENGINE EMISSIONS
SECOND EDITION — JULY 1993

This edition incorporates all amendments to Annex 16 adopted by the Council prior to 15 March 1993 and approved, on 11 November 1993, all previous editions of the Annex.

For information regarding the applicability of the Standards and Recommended Practices, on Environmental and the related matters in each chapter.

INTERNATIONAL CIVIL AVIATION ORGANIZATION
Special Report on Aviation and the Global Atmosphere

- Prepared at ICAO’s request
- Completed April 1999
- Covered both climate change and ozone depletion
Nitrogen Oxides (NOx)

- Produce ozone
- Reduce the atmospheric concentration of methane
Cloud Effects On Earth's Radiation

- High clouds
- Reflected solar radiation
- Outgoing longwave radiation
- Low clouds
- Incoming solar shortwave radiation
- Reflected by the surface
- Earth's surface
- Aircraft are estimated to contribute about 3.5% of the total radiative forcing of all human activity.
- The Assembly urged States to promote scientific research ... and asked for cooperation with the IPCC and other organizations in this area.
- IPCC to update information on aviation in 4th Assessment Report (AR4)
  - Due 2007

- ICAO is involved in the revision process of 1996 IPPC Guidelines which includes an update of the aviation emissions factors and other parameters
Kyoto Protocol

- Adopted in 1997
- Commits Annex I Parties (developed Countries) to individual, legally-binding targets to limit or reduce greenhouse gas emissions
  - Reductions of at least 5% between 2008-2012 compared to 1990 levels, AND TO
  - Pursue limitation or reduction of emissions of greenhouse gases from aviation bunker fuels, working through ICAO

Kyoto Protocol entered into force February 2005
ICAO and UNFCCC

- ALL parties have to report to the Convention on the emissions, including aviation emissions

- For Annex I - Domestic aviation emissions included in national totals

- International aviation emissions reported

- ICAO involved in a study on quality of aviation emissions data
Tracking Climate Change

- Aviation contributes to main scientific research projects
- In the framework of the CARIBIC and MOZAIC projects, sensitive measuring devices aboard long-haul aircraft collect data on the composition of the Earth’s atmosphere. Scientists worldwide benefit from this research, which helps them better understand the causes and developments of climatic changes.
ICAO and UNFCCC

- A35, Appendix H - requested ICAO to continue to develop policy options to limit or reduce emissions and to develop proposals and provide advice to UNFCCC; and

- to place special emphasis on the use of technical solutions while continuing consideration of market-based measures
Policy Options to Reduce Emissions

- Technology and Standards
- Operational Measures
- Market-based Measures:
  - Emissions charges
  - Emissions trading
  - Voluntary measures
Technology and Standards

- Technology can help, through improved engine or airframe design, achieve reductions in emissions
- To achieve certification and to be “licensed” to operate, aircraft engines must meet standards defined in Annex 16
Technology and Standards

Diagram showing:
- Taxi-in
- Take-off
- Climb-out
- Final approach
- Taxi-out
- 3,000 feet
Technical Issues

- \( \text{NO}_x \) Standard was first adopted in 1981 then made more stringent in 1993, when ICAO reduced the permitted levels by 20% for newly certificated engines and again in 1998 by about 16%, on average for engines newly certificated from 31 December 2003.
Technology and Standards

- Emissions database available from ICAO website
- Emissions standards ($\text{NO}_x$, HC, CO and smoke number)
Operational Measures

- Emissions savings come from improvements in air traffic management (ATM) and other operational procedures.

- $\text{CO}_2$ emissions are directly proportional to fuel burn.

- Optimize fuel consumption = reduced emissions.
Operational Measures

- Improvements in air traffic management (ATM) and other operational procedures could reduce aviation fuel burn by between 8 and 18%.

- Most important fuel saving opportunities come from CNS/ATM systems that will permit more direct routings and the use of more efficient conditions such as optimum altitude and speed.
Improvements in Flight Operations

- Opportunities for fuel conservation
  - Landing weight
  - Fuel reserves
  - Airplane loading
  - Route selection
  - Altitude selection
  - Speed selection
  - Flap selection
Reduce Weight

- Blanking off 1, out of 3 potable water tanks for “medium-haul” B777-200, prevents their use
- 100kg of water, per flight not loaded
- Annual savings estimated as
  - 380 tonnes fuel, 1200 tonnes CO₂
Reduce Weight

- Using one route as an example
- Weight reductions (LHR-NY):
  - B747-400 - 32.60 kg
  - B777-200 - 34.40 kg

Plastic Cutlery
Route Improvements

- Choose the most direct route possible
- ‘Great Circle’ is the shortest distance between 2 points on the earth’s surface
- Great circle may not be the shortest air distance when winds are included
• ETOPS allows for more direct routes
• Shorter routes = less fuel required
Altitude Selection

Optimum altitude:
Pressure altitude for a given weight and speed schedule that gives the maximum mileage per unit of fuel
Reduced Vertical Separation Minimum

- Taking advantage of operating closer to optimum levels
- Studies: conservative estimate: average 80kg fuel saving per flight in RVSM
- 10,000 flight daily in EUR RVSM
  - yearly saving 290,000 tons
  - yearly 913,500 tons less CO$_2$
  - yearly 4,350 tons less NO$_x$
## How Much is a 1% Reduction in Fuel Worth?

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<th>Airplane Type</th>
<th>Fuel Savings (Gal/Year/Airplane)</th>
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<tr>
<td>737</td>
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<td>777</td>
<td>70 000</td>
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<tr>
<td>747</td>
<td>100 000</td>
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</table>

(* Assumes typical airplane utilization rates)
• ICAO promotes various workshops on operational opportunities

• For information, see the ICAO website
What Are Market-Based Measures?

“are policy tools that are designed to achieve environmental goals at a lower cost and in a more flexible manner than traditional command and control regulatory measures.”

ICAO has looked at three types:

- voluntary mechanisms
- emissions charges
- emissions trading
Types of MBMs

- **Voluntary Measures**
  - government and other entity agree to take specified actions or meet specified goals

- **Emissions Charges**
  - a charge on the amount of emissions
  - revenues used to mitigate the environmental impact of engine emissions

- **Emissions Trading**
  - the total amount of emissions would be capped
  - allowances in the form of permits could be bought and sold to meet emission reduction objectives
  - open trading allows trading across sectors
Open emissions trading system is cost effective solution for CO₂

Voluntary measures advantageous for short-term implementation

Further studies should be carried out on levies and further guidance developed

More work needed on impact on developing countries
Voluntary Measures

- Seen as a possible short-term measure
- A33 urged Council to facilitate actions by developing guidelines
- A template agreement and guidance on voluntary measures to reduce aviation emissions was developed and is available on the ICAO website
- CAEP will report on State’s experiences
Local Air Quality Emission Charges

- Take account of past experience from States
- Take inspiration from concept of balanced approach
- Take account of CAEP Action Plan and
- Study cost effectiveness of the air quality charges
Emissions Trading

- ICAO commissioned a group of consultants to provide analytical basis for making recommendations on emissions trading system covering GHG emissions from civil aviation.

- Guidance is currently under development in CAEP and expected by the next Assembly.

- Some emissions trading schemes are currently operating (e.g., EU trading scheme).
• Action without study is fatal:
• Study without action is futile.
THE END